

THE RUMFORD KITCHEN LEAFLETS.

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SOME POINTS IN THE CHEMISTRY OF PROTEIDS.

Written for the Rumford Kitchen by JOHN J. ABEL.

THE proteids and substances so closely allied as to be classed with them are, next to water, the chief constituents by weight of the human body. Roughly speaking, the human body is sixty-five per cent. water, fifteen per cent. proteids and proteid-like bodies, while the remaining twenty per cent. is made up mainly of fat, a few per cent. of mineral constituents, and smaller quantities of other substances, such as the carbohydrates and extractions. When separated by chemical means from the salts, fats, and other substances with which they are closely bound up in living tissue, the proteids are seen to be non-crystalline in form, and easily affected by heat and chemical agents. In the body itself they must be thought of as existing either in a kind of solution in its fluids, as for example in blood, or in a more viscous condition in its tissues of firmer structure, but as soon as life is extinct many of them take on the more solid or coagulated form.

Many varieties of proteids are to be found in the various tissues. Thus, from the muscles may be isolated myosin and muscle-albumen, from the blood, serum-albumen, fibrinogen, paraglobulin, and haemoglobin; from the brain, neurokeratin and nuclein; from connective tissue and bone, collagen or gelatine-giving material;

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from the network of glandular structures, elastine and reticulin; from the hair and skin, keratin; and from the milk, casein.

These proteids and proteid-like bodies are all ultimately derived from the proteids built up by plants out of very simple inorganic constituents. The animal organism has the power of splitting up proteids that have been consumed as food, and of modifying them in many ways, so that varieties very different from those originally digested are deposited in the tissues; but it can not, like the plant, build up proteid anew out of, we might almost say, the chemical elements themselves. The animal body, then, takes its proteid either in the form of plant proteid or plant proteid previously transformed into animal proteid. Plant and animal proteids, though closely related, are by no means identical.

Only a few chemical elements enter into the composition of proteids. All contain carbon, hydrogen, oxygen, and nitrogen, and most of them also sulphur; several contain phosphorus in addition, and a few, iron or copper. Their general percentage composition varies within the following limits:

Carbon	.	.	.	.	.	.	50.0 — 55.0 %
Hydrogen	.	.	.	.	.	.	6.8 — 7.3 %
Nitrogen	.	.	.	.	.	.	15.4 — 18.2 %
Sulphur	.	.	.	.	.	.	0.4 — 5.0 %
(Phosphorus	.	.	.	.	.	.	0.42 — 0.85 %)
Oxygen	.	.	.	.	.	.	20.8 — 24.1 %

With the help of such analytical data, chemists are wont to establish by calculation what is known as the lowest empirical molecular formula of a substance, and by taking into account certain physical and chemical data arrived at in other ways, this empirical formula is changed into what is called a rational formula, one representing the molecular magnitude and the molecular structure of the substance analyzed. For proteids, however, not even a definite empirical formula has been arrived at in spite of the innumerable ultimate analyses that have been made of various proteids, and the chief reasons for this are the difficulty of de-

termining the chemical individuality of a given proteid or of its compounds, and the uncertainties introduced by minute analytical errors in the case of substances presumably containing so large a number of atoms in their molecule. An older formula, based on the analysis of purified white of egg that had been treated with strong caustic soda, and representing the lowest empirical formula, is $C_{72} H_{112} N_{18} S O_{22}$. Other analyses of so-called crystalline proteids, or more properly speaking, of loose compounds of proteids and mineral constituents, have led to formulæ representing very high molecular weights. Here, too, such difficulties present themselves that we must confess that we have no notion whatever of the true molecular weight of the proteids, and it goes without saying that we are equally in the dark as to their molecular constitution. So many chemists of repute, however, are working in this field that we may hope to see in the near future light thrown on this important question of biology.

In the absence of chemical data of a higher order, it has become necessary in the interests of medicine, biology, and other sciences, to classify these bodies in accordance with their behavior toward heat, acids, alkalis, metallic compounds, distilled water, dilute saline solutions, etc. Thus, serum-albumen, one of the chief proteids of the blood and egg-albumen are classed together, for they are both soluble in distilled water and in dilute solutions of common salt, and both coagulate on being heated to from 50° — 80° C. A closely allied class to which casein belongs are insoluble in distilled water and in weak solutions of common salt, but soluble in weak alkaline solutions and not coagulable when their pure alkaline solutions are heated. Two other classes constituting the albumoses and peptones result from the action of the digestive juices on the proteids of our food. These are in general extremely soluble in water and behave very differently toward precipitating reagents from those already named.

By the application of such chemical tests the proteids proper are classified into albumins, globulins, nucleo-albumins, albuminates, fibrins, albumoses, and peptones. In addition to these there

are other constituents of the body that we have referred to as proteid-like substances, which, while differing among themselves more decidedly than the groups that we have just named, yet resemble the proteids so much that they must be brought into connection with them. Some of these allied proteids contain a non-proteid residue like sugar in close combination with them. These are known as mucin, hæmoglobin, keratin, elastin, reticulin, collagen, gelatin, etc., and still other representatives are found widely distributed in the animal world.

Not only are the proteids that have been absorbed from our food variously modified within the body and built up into its structure as has already been intimated, but they are also constantly undergoing destruction as part of the material that furnishes the various forms of energy required. The final or refuse products of this destructive process are water, carbonic acid, and certain nitrogenous substances, chief among which is one called urea. This substance is excreted by the kidneys, and in the case of adults about an ounce is eliminated every twenty-four hours. But a large number of other nitrogenous substances, all derived from proteids, and all playing a more or less important rôle in the upward or downward chemical changes to which proteids are subjected, are also met with in the tissues and fluids of the body. Some of these other nitrogenous substances are uric acid, xanthin, sarkin, guanin, adenin, leucin, tyrosin, kreatin, and taurin. Many of these are, furthermore, of interest since we take them in considerable quantities every day with our meats, soups, etc., as natural physiological stimulants. Meat extracts, such for instance as Liebig's extract, afford a most convenient source for their preparation and study, notably for kreatin and sarkin. The active principles of tea, coffee, and cocoa are chemically intimately related to those nitrogenous "extractives" of meat to which the name of the xanthin group has been given.

The chemical steps involved in the formation of these various substances within the body tissues are still largely a matter of mystery. In order to elucidate the manner in which proteids may

break down or may be reconverted in the body, chemists have treated them with strong acids, alkalis, and other chemical agents under various conditions such as high temperatures and high pressure. The artificial decomposition of proteids in the laboratory has yielded us many of the intermediate products referred to, and, taken into account along with the results of physiological experimentation, has furnished us with at least a rough sketch of the chemical history of proteids from the moment of their entrance into the alimentary canal to the appearance of their fragments lodged in the tissues or circulating in the fluids of the body. To attempt this sketch here would however take us beyond the scope of this leaflet.

